Sooty Blotch of Pomaceous Fruits

BY

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Rome apples badly affected with Sooty Blotch

SOOTY BLOTCH OF POMACEOUS FRUITS[1]

ARTHUR SAMUEL COLBY, UNIVERSITY OF ILLINOIS

I. INTRODUCTION

Sooty blotch, and fly speck, which often accompanies it, which are sufficiently illustrated by Figs. 1 and 2 to make clear the meaning of these names, have been known in a general way in this country for almost nine decades, or since 1832, as the cause of a peculiar spotting or "clouding" of certain pomaceous fruits, especially apple and pear. The names adequately describe the appearance of these fungi, which are commonly found on the fruit. Occasionally other parts of the plant are affected. One or both fungi may be present on the same portion of the host, while if both are found they may be near each other or widely separated. The fungi may appear during the latter part of the growing season except where rainfall is scarce at that time. Such blemishes, while not the cause of decay, usually do cut down very materially the salability of otherwise good fruit.

Notwithstanding the conspicuous character of these fungi and their general distribution, which has resulted in numerous references to their occurrence and suggestions for their control, there has been comparatively little study to determine their morphology, and relation to other fungi. Some authors have held that sooty blotch is distinct from fly speck, others, that the two are merely different forms or aspects of the same fungus. Such opinions have resulted in much confusion, and a wealth of misinformation, handed down from one publication to another. In an attempt to clear up to some extent, such a chaotic condition, a morphological study of sooty blotch on pomaceous fruits was made by the writer. Brief mention is made of sooty blotch as it has been noted on the woody parts of other plants, in some cases with incidental studies of the same, if needed to throw light on common problems of morphology.

[1] The results presented in this article formed part of a thesis submitted by the author to the Graduate School of the University of Illinois in partial fulfilment of the requirements for the degree of doctor of philosophy in botany, May, 1919.

Sooty blotch is strictly superficial. It does not penetrate even the cuticle of the host, and causes no malformation or cellular injury. It cannot, therefore, in the strict sense of the word, be termed a disease and will not be so discussed at this time.

II. THE FUNGUS

Names. The sooty blotch and fly speck have been known for many years under a variety of names. Some authors have used but one common name to include both forms, while others have used two. The common names employed are the following: Fruit spot, ink spot, fly speck, sooty fungus, sooty mold, sooty spot, sooty blotch, cloud, while technically the fungi have been placed in the genera Monilia, Dothidea, Labrella, Xyloma, Sphaeria, Leptothyrium, and Phyllachora.

Practically all the common names listed are quite descriptive and on that account are suitable for common usuage. The name, sooty blotch, however, seems definite, and because of its general use, is here adopted as the common name of the fungus.

Much confusion has arisen through the lack of uniformity in names, common as well as scientific, by which the fungus is known. This has resulted in uncertainity on the part of anyone working in this field, as to exactly which fungus is meant by any one common or scientific name. It has therefore been thought wise to include in the bibliography all available references of importance, bearing on either of these fungi.

History. The vague and incomplete technical descriptions which have been given of these two fungi make it difficult for the student to be certain which fungus is meant. In early studies of the fungi, stress was quite naturally laid on the taxonomic side. Since 1894, however, the investigations have taken a practical turn, with only a few isolated examples of taxonomic or morphological studies.

What is now known as sooty blotch is first noted and briefly described in this country by Schweinitz (1832),

FIG. 1. Sooty blotch predominant on apple shown at right; fly speck on apple shown at left, x ⅔

as present on the epicarp of mature apples of the Newtown Pippin variety in Pennsylvania. Two years later, Montagne and Fries (1834) report a fungus on apples that they have received from Dr. Hussenot in Paris, which was either sooty blotch or fly speck. Sprague (1856) gives an interesting description of sooty blotch on apples and states that "the disease" is of common occurrence in New England. Von Thuemen (1879) reports finding what is probably sooty blotch in Italy.

From 1879 till 1894 nothing worthy of note was published, except the taxonomic studies of Saccardo (1883) and (1884). From 1894 on, plant pathologists at the various experiment stations in Canada and this country begin to report the occurrence of sooty blotch and fly speck, and offer suggestions for preventing them. Lamson (1894) of New Hampshire was the first to spray for sooty blotch, and was successful in controlling it. Powell, (1896) using the term "fly speck" to include both forms, discusses its occurrence in Delaware. About this time also, Taft and Davis (1895), and Beal (1897), report sooty blotch and fly speck as being troublesome in Michigan. Also in 1897, Selby (1897) discusses "sooty fungus" and "fly speck fungus" in Ohio. The next year, Sturgis (1898) in Connecticut, gives a somewhat detailed account of the appearance, causal nature, and control of sooty blotch. Beach *et al.* (1899) offer measures for the control of these two fungi, in New York. In 1900, Selby again (1900) describes sooty blotch and fly speck, and recommends control measures in Ohio. Orten (1902-07), in his yearly "Summary of Plant Diseases in the United States," incorporated in the Department of Agriculture Year Books, from 1902 to 1907, when the service in that form was discontinued, reports as to the occurrence of sooty blotch and fly speck, the names used interchangeably. He finds the fungi to be generally prevalent over many of the northeastern and middle western states, with isolated exceptions farther west and south. The next year, Faust (1903) lists "sooty mold" as the cause of a minor but very common trouble in Missouri. Lamson,

the same year (1903), reports satisfactory results in control of sooty blotch while spraying for apple scab.

The first notice the writer has seen of the troubles in Canada, is that by Macoun (1903), who discusses the "sooty fungus or fly speck fungus" with reference to its occurrence in Canada and methods of treatment. Sheldon (1905) finds the trouble prevalent in West Virginia. Wilcox (1905) states that sooty blotch is common in Alabama, and discusses the characteristics of the fungus as it appears in that state, with recommendations for its control. Clinton (1906) believes that sooty blotch is "one of the most serious fungous troubles of the apple in Connecticut". The presence of fly speck in Maryland is noted by Norton and Symons (1907), and recommendations for spraying are given. The fact that the fungus, which is called sooty blotch and fly speck, is less common in Maine than farther south, is emphasized by Morse and Lewis (1910).

The first recorded appearance of sooty blotch in England is by Salmon (1910), and anxiety is expressed that it may become serious, like other troublesome fungi imported from America. The same year, Stevens (1910) gives fly speck a minor place among North Carolina fungi, and claims its control by proper spraying. Howitt and Hayhurst (1911) find "fly speck fungus" on woody portions of various orchard plants in Arkansas, though they refer to no host plants by name. Howitt (1911) briefly discusses sooty blotch in Canada, with suggestions for control. Ballou (1912) gives results of spraying experiments in sooty blotch control, in Ohio. Beach (1912) implies the common occurrence of the two fungi in Iowa, by including recommendations for their control in a spray schedule, while others; Brooks (1912), Clinton (1912), and Quaintance and Scott (1912) in the same year publish spray schedules, the use of which is intended to hold the troubles in check.

In 1916, Salmon and Wormald (1916) find sooty blotch on the pear, for the first time, in England. From 1916 to the present time, still greater stress has been laid on spraying experiments in discovering the best methods of

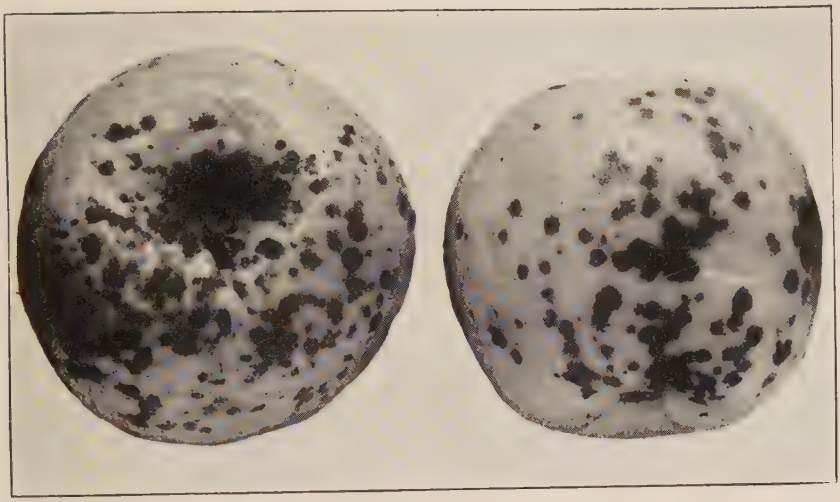


FIG. 2. R. I. Greening and Grimes apples before storage x ¾

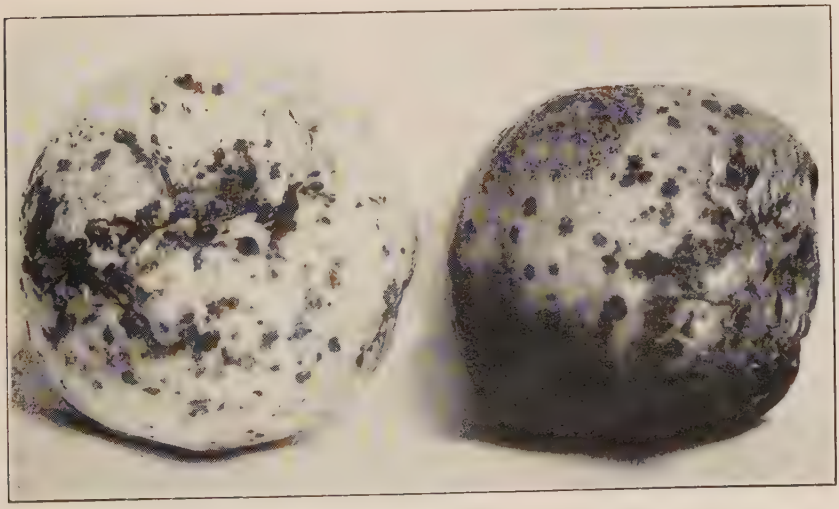


FIG. 3. Apples shown in Figure 2 after ten months in storage

control of orchard fungi, and Blair *et al.* (1916), Winn (1916), Howitt and Caesar (1917), and Pickett *et al.* (1918), are among those reporting results of various spray treatments in sooty blotch control.

General Appearance. Sooty blotch, as its name implies, is made up of spots or blotches, appearing to the naked eye as smears of soot, at first brown in color, darkening with age. The spots, though somewhat irregular in outline, have a tendency to be circular (Figs. 1, 2). Individual areas may vary in diameter from less than .1 cm. to .8 cm., but in most cases before the larger dimension is reached, two or more blotches will have coalesced, tending to cover the surface of the fruit.

On closer examination, sooty blotch exhibits a radiating structure of olive brown mycelial threads which extend to form a common center and branch to form a colony, fern-like in appearance.

In all essential particulars, sooty blotch, as found on stems and twigs of various hosts, is similar in appearance to that described on the fruit.

Economic Importance. Sooty blotch is an orchard trouble of considerable importance, in the sections of this country and Canada where it is commonly found. Otherwise high class fruit, when spotted with the fungus, is reduced materially in market value because of the disfiguration. According to Winn (1916), fruit is reduced at least one-half in selling price if sooty blotch or "cloud" is present, while Quaintance and Scott (1912) state that such blotched fruit is rendered "practically unsalable".

Wholesale apple buyers in Champaign, Illinois, inform the writer, that in the contract they make with the orchardist to buy his crop, it is expressly stipulated that no "clouded" fruit shall be packed in either the No. 1 or No. 2 grade, but must be barrelled separately, and at a discount in price of from twenty-five to fifty per cent. If the "cloudy" stock has to be discounted more than fifty per cent, it is handled only on a consignment basis.

In an examination of apples offered for sale in thirty Champaign-Urbana, Illinois, grocery stores in the fall of 1917, blotched fruit was found in nearly every case. Some of the worst appearing fruit was found in the highest class stores and vice versa. The selling price was from thirty to fifty per cent higher on clean fruit than on that heavily coated. It was evident, however, that where the trouble was comparatively mild, little attention was paid to it by the customer and still less by the dealer. The fungus is less noticeable on dark colored fruit and here seldom retards retail sale, if sooty blotch is the only blemish present.

Although a similar fungus is mentioned as being found on pears in Italy (von Thuemen 1879), nothing is known with relation to its economic importance in that country. In England, Salmon (1910), in reporting it as a new disease there, writes, "if sooty blotch becomes common * * * * it is likely to prove troublesome by damaging the look of well grown apples and thereby interfering with the practice of marketing the best apples in boxes".

Since the fungus is strictly superficial, fruit on which it is present is injured only in appearance. It has been held, (Wilcox 1905, and Hesler and Whetzel 1917), that in case sooty blotch is present, the fruit may shrivel up and permit early decay. However, with observations on hundreds of apples from Illinois, Ohio, and Alabama, stored under various conditions, there was no more shriveling on apples wholly or in part coated with the fungus, than on clean fruit.

Various opinions have been held as to the increase in size, or the spread, of sooty blotch in storage. Macoun (1906) states, that "unfortunately, the sooty fungus spreads in storage", while Salmon (1910), reports, that "it is quite clear that sooty blotch * * * * spreads on stored apples". Selby (1897), however, does not believe the fungus spreads in storage, while Sturgis (1897) finds no evidence of increase, on fruit in storage two months.

Several hundred blotches on eighty apples of different varieties, grown in various states, were carefully counted

FIG. 4. Photographs of the original packet (below) and its contents (above) of Dothidea promigea Schw. in the Herbarium of the Academy of Natural Sciences of Philadelphia.

and measured. The apples were then placed in ordinary cold storage at 0° C. on October 12, 1917. Examinations of these blotches were made from time to time, but no evidence of further growth was found. The last apples were removed from storage, August 10, 1918. Figs. 2 and 3 are from photographs of the same apples, Grimes and Rhode Island Greening, taken before and after being stored, under the above conditions. Aside from a slight shriveling, which was noticed on the checks, as well as on the fruit bearing the fungus, no change in general appearance was evident. There was no enlargement of the individual blotches.

Contrary to the statement made by Stevens and Hall (1913), and Sears (1914), that sooty blotch can frequently be entirely rubbed off with a cloth, the writer has not found it generally true in his handling of apples from Alabama, Illinois, Ohio, and New Hampshire. Boxed apples, Winesaps, from the state of Washington, offered for sale on a fruit stand, at Champaign, Illinois, had been polished to the usual degree found at such places. They were, nevertheless, markedly spotted with the fungus. Such facts indicate the impossibility of easily removing evidence of the trouble in the orchard, through the ordinary picking and sorting operations, where canvas gloves are worn by the workers.

Geographical Occurrence. Comparatively little is known regarding the occurrence of sooty blotch, in countries other than the United States and Canada. The brief statement by von Thuemen (1879), that the fungus occurs in Italy, is practically the only citation we have, which refers with certainty to sooty blotch on the continent. In England the fungus is reported on apples by Salmon (1910), and on pears by Salmon and Wormald (1915).

Macoun (1903), in reporting the presence of "sooty fungus or fly speck fungus" in Canada, states that it is not common in Ontario, but was found the previous year. Later (Macoun 1907), he reports the trouble as usually confined to southwestern Ontario. Howitt (1916) states

that sooty blotch is common in the Guelph (Ontario) market.

In the United States, it was indicated through information in the records of the Plant Disease Survey, and correspondence with plant pathologists of the different states, that with the possible exception of Georgia, sooty blotch is present in every state east of the Mississippi River, as well as the entire tier of states from north to south, adjoining these Mississippi Valley states. Nebraska, Kansas, Idaho, and Washington are the only other western states to report the fungus.

Morphology.

Methods. It was found for the purpose of the present study that the best methods of securing suitable mounts were the following:

Sections bearing the fungus were cut as thin as possible, parallel to the surface of the fruit, using where convenient, light colored varieties. These strips of epidermis were moistened in water, then placed cuticle downward, and carefully scraped to remove as much of the tissue as possible, killed in absolute alcohol, dehydrated, cleared with xylol and mounted in Canada balsam. Some difficulty was encountered in making accurate observations of the cell structures of the fungus, owing in some cases to the density of the epidermal cells of the host.

Attempts to utilize the methods recommended by Stevens (1916), that of lifting off the superficial mycelium by means of a thin film of celloiden, applied and allowed to dry, were successful only on certain apples. Some strikingly good results were obtained by this method, however, especially in removing pycnidia.

A third method was that of cutting microtome sections 10μ in thickness, of material imbedded in paraffin. The sections were fastened to the slide in the usual way, the paraffin removed by xylol, the slide rinsed in alcohol and then left in safranin stain over night. The next morning, the sections were decolorized sufficiently with acid alcohol, dehydrated, cleared, and mounted in balsam. The

FIG. 5. Sooty blotch on pears, of the varieties, Kieffer, Clapp, and Wadleigh, x ¾

safranin stain was employed to differentiate the cuticular layer of the host, which lies just below the fungus.

The Thallus. The vegetative thallus of sooty blotch is made up of a mycelium of profusely branched hyphal threads. The mycelium is composed of cells, olivaceous in color, according to Saccardo's "Chromotaxia" (1891), slightly constricted at the septa, usually isodiametrical in shape (Fig. 12). There is considerable variation in cell dimensions, measurements of width varying from 2-5μ, and of length from 2-8μ. Individual cells, groups and chains are often found with walls relatively thicker than usual, and darker in color than is typical. During the early growth of the mycelium, all the hyphal threads appear to extend in the same plane. Lateral branching is initiated very soon, however, which may result in such a profuse interlacing and crossing, that a mycelial crust results.

Several variations in the form of the thallus have been observed. In one, which appeared commonly on Rhode Island Greening apples, and which is illustrated in Fig. 2, the thallus starts from a single mycelial cell, from which, by division, three or more cells are cut off, and initiate profuse branching in many directions. Most of the cells so produced, continue to divide in their turns, at several points on their periferies, resulting in a much branched proliferation. The cells making up the main branches are prominently set off, under the microscope, by their thick walls and septa, and regular shape. They, in turn, branch laterally in both directions, often producing cells of peculiar shape (Fig. 24). Constant enlargement of the thallus by terminal growth, as well as thickening, by filling in of spaces, at first open, between the branches, results in a dense plate of closely packed, sometimes angled cells. This cell plate may occupy a small area in the center of the thallus, and measure less than 20μ in diameter. Its growth continues, however, in proportion to the proliferation of the thallus, and numerous plates have been found to measure over 720μ in diameter. The branching hyphae in all cases observed, extend out from the cell plate, the whole giving the appearance of

a fern-like colony (Fig. 7), and the type will be classified under that name.

A second type appeared rarely, and was observed only on the Huntsman apple. It somewhat resembles, under the low power, a cross-section of a honey comb (Fig. 11), and may, therefore, be referred to by that name. On examination with the oil immersion lens, however, almost hyaline hyphal threads, in some instances with hardly distinguishable septa, were observed, branching irregularly over the areas included in the honey comb like cell aggregations. The latter, on their part, are composed of sometimes short, many septate hyphae; sometimes masses of cells, irregularly grouped and bounded, but with cell walls and septa thicker and darker, and with denser cell contents, than of the hyphae in the more open spaces. The cells of this type measure 2-3 x 2-5μ, being in many instances longer than broad.

A third thallus type (Fig. 12), which may be named the reticulate type, is characterized by a very large number of long, tenuous branches, gradually radiating from a common center. In general, the cells are 2-4 x 2-5μ, and commonly regular in shape. No peculiarities in budding were noted such as were cited for the first type. Definite anastomosis of cells originating from the hyphal branches which lie more or less parallel, coupled with this regular branching, are characteristic of the type. Branches, composed of two and three hyphal rows closely appressed, were commonly noted.

In the first stages of development of all thallus types, the hyphal threads appear to extend in the same plane. Within a short time, however, there is noted a tendency to form cell aggregations, or a piling up of cells. This results in the formation of large numbers of minute black specks (Fig. 18), generally invisible to the naked eye, and usually not more than 100μ in diameter, interspersed among the mycelial threads. These are not to be confused with the cell aggregations making up the so-called fly specks (Fig. 18), however, which are much larger, up to 270μ in diameter, and much less numerous, when present at all. On the other hand, the minute

Fig. 6A. Grimes apples affected with sooty blotch, before immersion in Javelle water

specks are cell formations, which have to do with reproduction, and will be discussed under the next heading.

A cross section of the blotch mycelium (Fig. 33), shows its superficial nature, and the characteristically irregular looping and interlacing of the hyphal threads, some of which are darker in color than the others.

Pycnidia. The pycnidia are scattered throughout the thallus. Though often indistinct to the naked eye, they are easily discernable, individually, with a magnification of ten diameters. They are usually found to be separate, though occasionally two or three are so closely pressed together as to appear united. Their presence intensifies the dark, almost black, appearance of the blotched areas. On apple fruit they are often very numerous, averaging about 1,000 per square centimeter. This number is considerably greater than the corresponding one for the same unit of area on apple bark. Mature spore-bearing pycnidia were very rarely found.

Typical pycnidia (Figs. 10, 13) measure, when mature, about 20-40μ in thickness, and 70-100μ in diameter, and are dimidiate, i. e., as seen from above, they present an approximately circular contour; in cross section they are found to be flattened at the base and with a top uniformly rounded.

They appear under the high power as closely tangled, dense, reticulate masses of fine mycelial threads, with hyphae extending away in several directions (Fig. 30). No ostiole has been observed, its purpose being served by an aperture of a different nature, the opening of which begins with the appearance of a pale spot at or near the central region of the pycnidium. Later stages show the breaking down of the cells in this region, then one or more cracks appear, and fragments drop out, leaving a large, more or less jagged opening (Fig. 22).

Within the pycnidium are borne conidia with paraphyses. The tissue, of which the interior of the pycnidium is composed, is gelatinous, as are the conidia and paraphyses, which are separated with difficulty after being forced from the pycnidium (Fig. 21).

In the accompanying diagram (Fig. 34), are shown in cross section, the relative positions of the various parts of the pycnidium. The pycnidium (a), is seen to be entirely above the cuticle (b), and to possess a solitary subglobose locule (e). The mycelium (f) leading up to the pycnidium proper, is extremely dense, and it is seldom that its cellular structure can be recognized. It approaches the locule from either side, the locule being in a way buttressed by the ends of the former. The locule itself is surrounded by cells of irregular shape (d), somewhat gelatinous in character, and thinner walled and lighter in color than those of the thallus (f), individual cells in the inner layer alone, being recognizable. Cellular structure of this nature extends above the locule, making up the upper layer (c) of the pycnidium. In the angles (g), made betwen the buttressing mycelium and the locule, as well as along the base of the pycnidium just below the locule, the cells are still lighter in color than those immediately above the locule.

Pycnidial Formation. According to DeBary (1884), and Kempton (1919), pycnidia may arise by one of two methods, which they designate as "symphogenous" and "meristogenous": "symphogenous" when the young hyphal threads interlace to form at first a loose network, later one gnarled and knotlike, "meristogenous" when the pycnidial primordium arises by intercalary growth on one or more cells of one hyphal branch. Variations in these two methods have also been noted, such as simple and compound modes of each, or even a combination of the two methods.

The various stages in pycnidial formation in sooty blotch, have been followed on apple skin by mounting representative bits at different times in the year. Pycnidial development was observed to be in progress in September, but it is not usually complete until the winter is over, and appears to proceed naturally on material wintering out of doors.

Pycnidial formation in sooty blotch is usually symphogenous (Figs. 27-30), though the behavior of the

FIG. 6B. Grimes apples affected with sooty blotch, after immersion in Javelle water

hyphal threads is variable and examples may be found of different modes.

In one developmental series, representative of the symphogenous method, formation of the pycnidial primordium begins by the lateral budding of one or more cells of a hyphal thread (Fig. 28), cells of various shapes and sizes being cut off. A second hypha, lying beside the first, buds, and the branches resulting from these two parent hyphae unite. In other cases, this second hypha is included in the formation, by the uniting of a branch of the first hypha with a cell of the second (Fig. 27). Occasionally, additional main mycelial threads may become involved.

From this stage on, regardless of how initiated, the process is one of rapid branching, with many connecting links formed between the hyphal threads (Fig. 29). Much looping and interlacing of main and branching hyphae ensues, which results in a dense mass of mycelial cells. The outer portion or covering then becomes membraneous and darkens in color. Further internal development and cell differentiation of the mass, results in a pycnidium (Fig. 30).

Conidia. Conidia were rarely found, as scores of seemingly mature pycnidia were examined without evidence of fructification. The method of procedure was as follows: Bits of apple skin on which it was thought good material might be present were placed in concentrated potassium hydroxide over night. The next morning the skin was washed and the pycnidia removed to a glass slide, in a small amount of water. A cover glass was placed on the material, and individual pycnidia observed under the low power, were forced open by careful pressure with the scalpel. Where conidia were observed extruding through the characteristic slit, they were stained with iodine.

The conidia (Figs. 23, 31), are almost hyaline, one-celled, and while varying in shape, are somewhat oblong, straight or slightly curved, muticate, measuring 10-20 x 4-7μ. The conidia appear to be sessile, or borne

on very short conidiophores arising as lateral branches from the mycelium, which forms the base of the sporogenous structure.

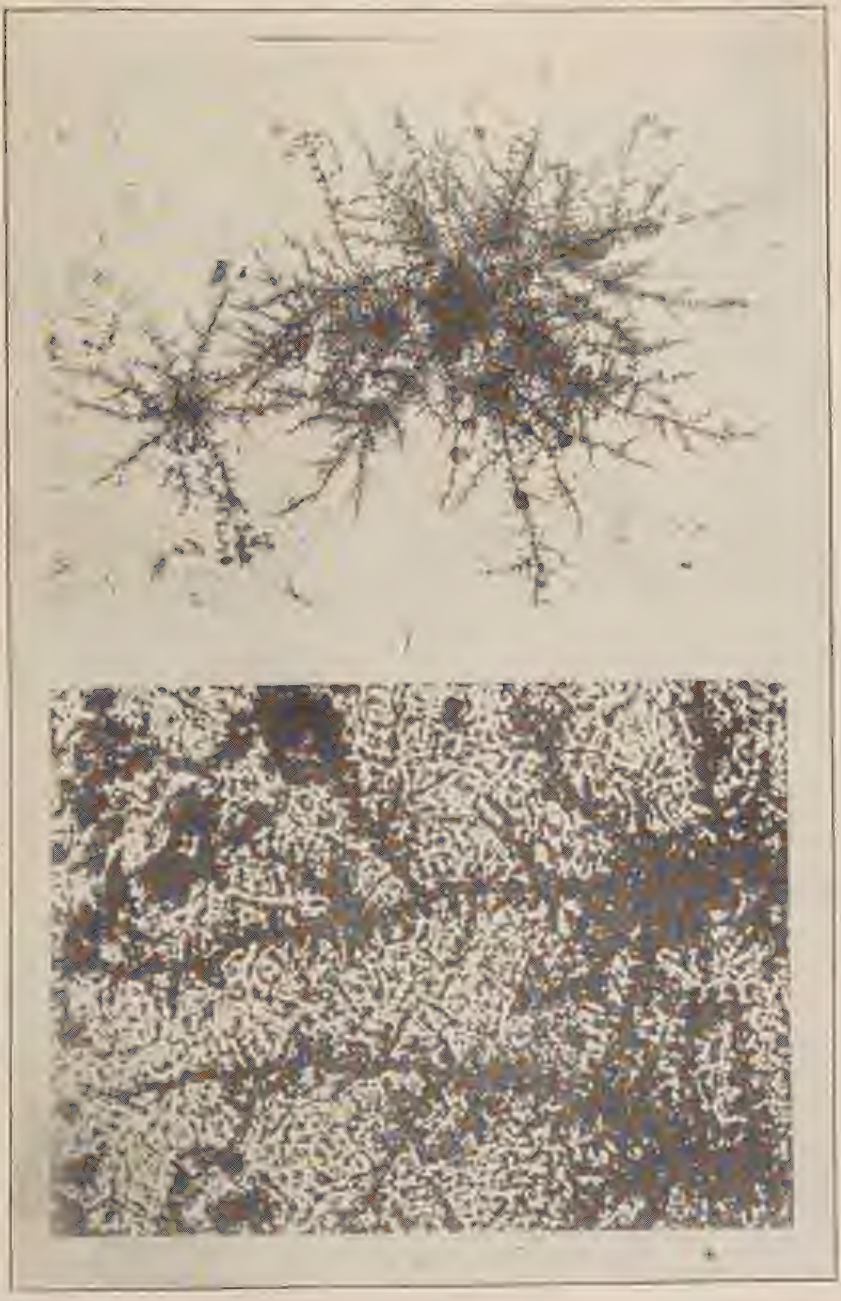
Paraphyses. A fact of importance to be noted is the presence of copious paraphyses (Figs. 23, 32). They are slender, blunt, gelatinous, and many-septate, and extend among and far beyond the conidiospores. In various genera of the perfect fungi, the presence or absence, and the shape and size of paraphyses are important characters in differentiating these genera. Such structures are very much less common in the imperfect fungi and are here rarely used as generic characters.

However, Saccardo, in the "Sylloge Fungorum" uses the presence of paraphyses as a generic character in limiting *Lasiodiplodia,* and he also describes paraphyses in connection with many species of *Chaetodiplodia.* Higgins (1916), in his discussion of the nomenclature of plum wilt, which he places in the genus *Lasiodiplodia,* states that "the presence of paraphyses seems to be the most constant character of the pycnidia".

Chlamydospores. What appear to be chlamydospores have been observed often in examination of thalli of the fern-like type (Fig. 7). These spore-like bodies may be described as dark brown, thick walled, sometimes angled cells. They probably originate through the breaking apart of single cells of mycelium. It is certain that these chlamydospores initiate new colonies, since in thalli containing but 4-7 cells (Fig. 26), as well as in those much larger (Fig. 24), the chlamydospores are still easily recognizable near the center of the thallus.

Histological Relation. Sections of apple and pear fruits, more or less coated with sooty blotch, after being stained with the safranin, showed clearly that the statement generally made, affirming the superficial nature of the fungus, is correct. In no case was the cuticle penetrated, or any of the epidermal cells or those below, disturbed, or their appearance altered from the normal, when sooty blotch was present. This fact is well illustrated with respect to the pear, in Fig. 14, and the apple,

PLATE I



in Figs. 13 and 15, as well as in Fig. 34, previously discussed, where the relative position of the pycnidium to the cuticle is shown.

These observations are of interest, also, in another connection. According to Beach (1899), Clinton (1901), Lamson (1903), and Salmon (1910), sooty blotch, on superficial examination, has often been mistaken for apple scab. Since apple scab is subepidermal, a cross section of an apple fruit affected with scab would show a true diseased condition of the host, which condition is entirely lacking where sooty blotch, alone, is present.

Taxonomy. In 1832[2], Schweinitz published the species *Dothidea pomigena,* under the section Asteroma, the description reading as follows:

"1909 *D. pomigena* L. v. S., frequens in maturis Pomis dictis "Newtown Pippins". Pennsylv.

"*D. pomigena* maculis orbiculatis laxis, e fibrillulis tenerrimis nigris reticulato radiantibus, plerumque sterilibus. Cellulis in centro aggregatis, applanatis majusculis. Maculis vix unquam ¼ uncialibus."

The original specimen is now in the Schweinitz collection, in the Herbarium of the Academy of Natural Sciences of Philadelphia, Pennsylvania. Both the packet and its contents were kindly photographed by Dr. J. W. Harshberger, and appear as Fig. 4.

It will be noted that Schweinitz was uncertain as to the name to apply to the fungus, in that he first labelled the packet *Dothidea fructigena,* then changed it to *D. pomigena.* The packet also states that the fungus was formerly known as *Monilia fructigena.*

It is not clear why Schweinitz placed the fungus in Dothidea, a genus with the stromata formed within the tissues of the host plant, and later becoming erumpent.

[2] Some question has arisen as to the year of publication, Sturgis (1898) stating it to be 1831, while Clinton (1901) gives it 1834. The matter is cleared up by the following statement in a recent letter to the writer, from Dr. J. H. Barnhart, Bibliographer of the New York Botanical Garden: "The paper by Schweinitz, "Synopsis fungorum in America boreali media degentium", was published in 1832, not 1834 (see North American Flora, vol. 9, page 451). The volume title-page is dated 1834, but this paper constitutes Part 2 of the volume, dated 1832 (I have seen several copies in their original covers) and there is no doubt that it was issued in that year."

It is certain, however, that the fungus of Schweinitz is what we now know as sooty blotch. Sturgis (1898) translates Schweinitz' description of *D. pomigena* as follows: "Spots orbicular, loose, (in texture?) (composed of) a radiating network of very delicate black fibrils, for the most part sterile. Cells in the center aggregated, expanded, comparatively large. Spots hardly over ¼ inch (in diameter). Common on ripe apples known as 'Newtown Pippins', Pennsylvania;" and concludes that "the sooty disease * * * * is probably identical with the fungus observed by de Schweinitz on Newtown Pippins".

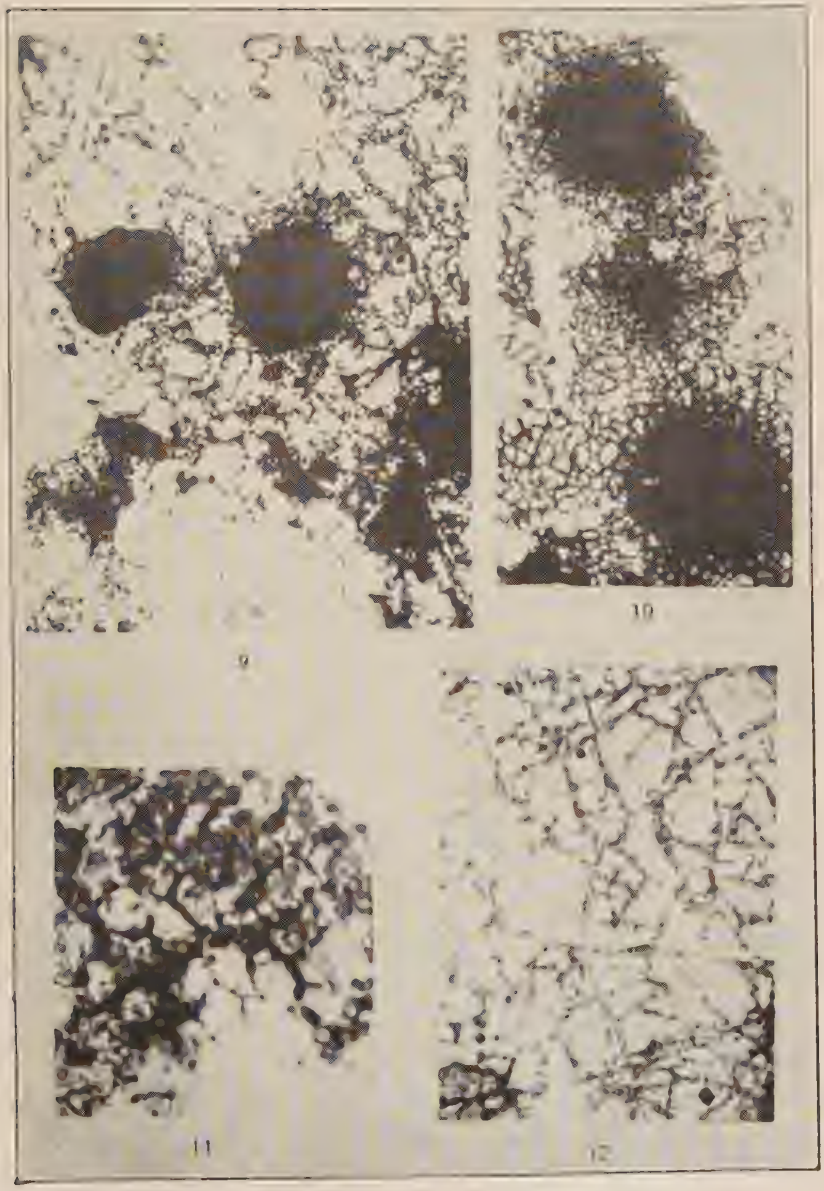
Clinton (1901) in his study of apple scab, after an examination of Schweinitz' original specimen of *D. pomigena,* concludes it is not scab as some botanists have suspected, "being more like the fly speck fungus in its macroscopic appearance". Clinton's statement has misled many succeeding investigators who have reasoned that *Dothidea pomigena* Schw., later changed to *Phyllachora pomigena* by Saccardo, (1883) is indeed fly speck. The writer was not convinced as to this fact and correspondence brought out the following: Clinton in a recent letter[3] states with regard to *Dothidea pomigena,* "What I wished to satisfy myself of at the time, was that it was not apple scab. I am not sure that at that time I had a very distinct idea of sooty blotch so may have thought it resembled the fly-speck fungus because I did not distinguish between them".

In a letter[4] from Harshberger, he states after an examination of *D. pomigena* Schw., at Philadelphia, that the fungus is in all probability sooty blotch, rather than fly speck, since the areas are diffused and there are no specks.

Since Schweinitz included *D. pomigena* under the section Asteroma as he understood it, (cf. original description), Sprague (1856) lists sooty blotch as *Asteroma pomigena* Schw., among a number of fungi collected near Boston and named by M. A. Curtis. Later in the same year, Sprague (1856) describes, with a specimen, the

[3] Letter of April 14, 1919.
[4] Letter of March 14, 1919.

PLATE II



sooty blotch fungus, using the same name as before, *Asteroma pomigena* Schw. He mentions the presence of minute black perithecia seated upon the mycelium, though he was not able to find any evidence of spores.

Saccardo (1893), after giving Schweinitz' Latin description of *D. pomigena,* renames the fungus, which thus becomes *Phyllachora pomigena* (Schw.) Sacc. The reason for this transfer is not clear, since Phyllachora has a well defined stroma within the host tissues, a character which is entirely lacking in sooty blotch. No evidence of the existence of ascospores of *P. pomigena* (Schw.) Sacc. is on record. Furthermore, Theissen and Sydow (1915), in their monograph on the Dothideales, list *Phyllachora pomigena* (Schw.) Sacc. under "Species Phyllachorae delendae".

Montagne and Fries (1834), published the species *Labrella Pomi.* Although the description is meager and not conclusive, it probably refers to fly speck.[5] Saccardo (1879), after repeating the description of Montagne and Fries, renames the fungus *"Leptothyrium? Pomi",* although he reports no spores. Later, Saccardo (1884) lists this fungus as *"Leptothyrium Pomi* (Mont. et Fr.) Sacc."

The name *L. Pomi* as above is commonly found in the literature to refer to fly speck, until Selby (1900) published "Sooty Fungus and Fly-speck Fungus * * * * *Leptothyrium pomi* (Mont. et Fr.) Sacc." He thus was the first to group the two fungi under the same technical name.

Selby mentions no investigations to prove the identity of the two fungi. The nearest approach to work of this nature was that done by Floyd, and reported by Duggar

[5] Since the above was written, positive evidence has come to light which substantiates the writer's statement. Through the kind offices of Doctor Wm. Trelease, Head of the Department of Botany, University of Illinois, three mounts were prepared from Montagne and Fries' No. 847, preserved in the Montagne Herbarium in the Museum of Natural History in Paris. The Curator of the Museum kindly sent the mounts to Doctor Trelease, who turned them over to the writer for study. The tissues are somewhat tangled as the material was cut free hand, nevertheless, the characteristic structure of fly speck is clearly evident. The mounts have been forwarded to Doctor J. W. Harshberger to be placed in the Herbarium of the Academy of Natural Sciences of Philadelphia.

(1909), who states that " the sooty blotch and fly speck are apparently stages of the same fungus" and provisionally refers to them as one fungus, though the evidence on which he bases his conclusions is not presented.

Since the publication of Duggar's book (1909), *Leptothyrium Pomi* (Mont. et Fr.) Sacc. has been quite generally accepted as the technical name for the two fungi, though this usage is not universal. In a recent letter,[6] G. R. Lyman of the U. S. Dept. of Agriculture, Plant Disease Survey, states that most of their collaborators refer to *Leptothyrium Pomi* (Mont. et Fr.) Sacc., as the cause of sooty blotch, and a smaller number attribute fly speck to this fungus. Sheldon, Cook, and Clinton refer to *Phyllachora pomigena* (Schw.) Sacc., as the cause of sooty blotch.

The following herbarium specimens were examined. The label on the packet is given as well as the herbarium or set of exsiccati from which the specimen was received. In the column headed "sooty blotch" are placed the names of the specimens classified by the writer as such: in the column "fly speck" are placed those classified by him under that name.

SOOTY BLOTCH

Phyllachora pomigena Schw. Sacc. Pirus malus. Winchester, Va. Oct. 21, 1908. Com. M. B. Waite. Det. M. B. Waite. From U. S. Dept. of Agr.

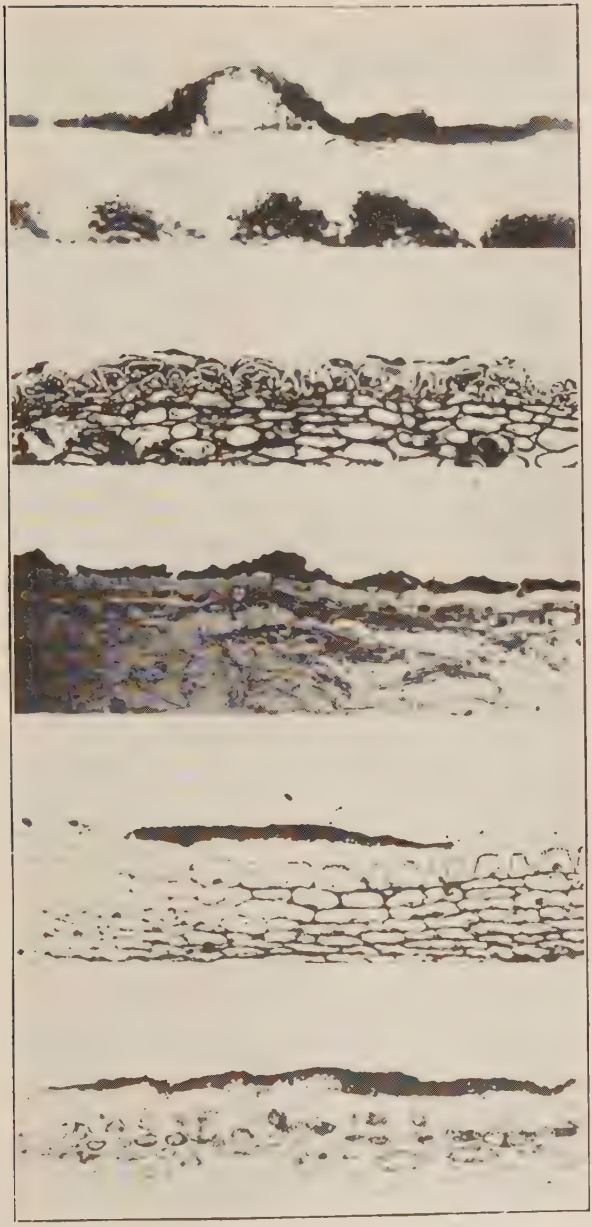
Phyllachora pomigena (Schw.) Sacc. From Giltner in Hamilton Co. Collector Mrs. E. D. Snider, 22 Sept. 1909. Herbarium of Plant Pathology, Dept. of Agricultural Botany. Univ. of Nebr. Plant Disease Survey. From U. S. Dept. of Agr.

FLY SPECK

Disease of Malus malus "Genitan". Caused by *Leptothyrium pomi.* From Red Cloud. Collector J. M. Bates, Jan. 31, 1908. Herbarium of Plant Pathology, Dept. of Agricultural Botany, Univ. of Nebr. Plant Disease Survey. From U. S. Dept. of Agr.

[6] Letter of March 10, 1919.

PLATE III



Leptothyrium Pomi, Mont. & Fr. Pirus malus. W. Va., Mar. 24, 1909. Comm. L. C. Corbett, Det. M. B. Waite. From U. S. Dept. of Agr.

Disease of Malus malus. Caused by *Leptothyrium pomi* (Mont. & Fr.) Sacc. From Giltner in Hamilton Co. Collector Mrs. E. D. Snider, 22 Sept. 1909. Herbarium of Plant Pathology, Dept. of Agricultural Botany, Univ. of Nebr. Plant Disease Survey. From U. S. Dept. of Agr.

Ellis & Everhart. North American Fungi. Second Series. 2174 *Leptothyrium Pomi* (Mont. et Fr.) On apple skins. Chicago, Ill. Col. W. W. Calkins, Univ. of Ill. Herb.

de Thuemen Mycotheca universalis 1483 *Labrella Pomi* Mntg. et Fries in Ann. sc. natur. 1843. I. p. 347. Mntg. Syll. plant. cryptog p. 272. Autria inferior: Wien in Pyri Mali Lin. fructibus servatis. Apr. 1879, leg de Thuemen. Univ. of Ill. Herb.

C. Romeguere. Fungi selecti exsiccati 6357 *Leptothyrium Pomi* (Mont. et Fr.) Sacc. Syll. Ill., p. 632; *Labrella Pomi,* Mont. Grognot, flore de Saone et-Loire, p. 136 f Crataegi.

Sur fruits de Crataegus oxyacantha mars 1893. F. Fautrey. Univ. of Ill. Herb.

In view of the morphology of the sooty blotch fungus, as described on the previous pages, it is obvious that it does not belong to any of the genera just discussed, and, moreover, that it possesses characters sufficiently striking and distinctive to warrant the erection of a new genus to receive it. For this I propose the name *Gloeodes,* gelatinous, referring to the gelatinous interior of the pycnidium, with the following generic description: *Gloeodes* nov. gen.

Mycelium strictly superficial, dark colored, septate, profusely branched, often anastomosing, constituting a thallus, often fern-like in appearance but occasionally of other types; pycnidia dimidiate, membrano-carbonous, interior gelatinous; paraphyses present; conidia oblong, one-celled, hyaline.

The type of the genus is

Gloeodes pomigena (Schw.) nov. comb.

Dothidea pomigena Schw., Trans. Am. Phil. Soc. n. s. *4*:232, 1832.

Asteroma pomigena (Schw.) fide Curt. in Sprague, Proc. Boston Soc. Nat. Hist. *5*:325, 1856.

Phyllachora pomigena (Schw.) Sacc., Syll. Fung. *2*:622, 1883.

Leptothyrium Pomi Selby, Ohio Agr. Exp. Sta. Bul. 121:12, 1900, as to sooty blotch only, the original idea of *L. Pomi* having reference to the fly speck fungus alone.

Pycnidia dark brown, dimidiate, scattered or aggregated, superficial, rupturing irregularly; conidia oblong, sometimes slightly curved, one-celled, hyaline, 10-20 x 4-7μ; conidiophores short or lacking; paraphyses septate, gelatinous, slender, blunt, longer than the conidia.

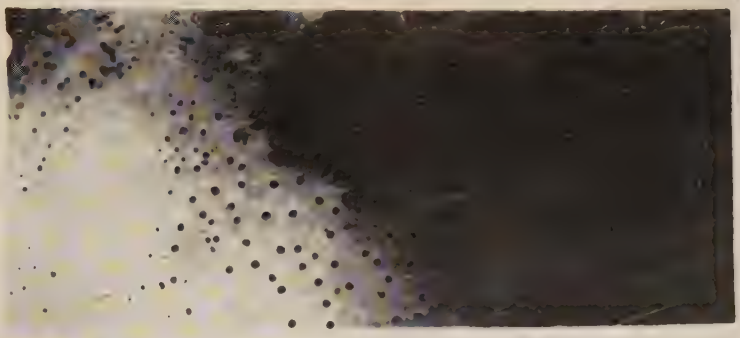
Hab. fruits and stems of certain species of Pyrus.

Host Considerations. Sooty blotch of pomaceous fruits is very common on the apple, Pyrus Malus L. (Fig. 2), appearing less often on the pear, Pyrus communis L. (Fig. 5). The literature available does not record with certainty, the occurrence of sooty blotch on any other hosts. Duggar (1909) reports what was either sooty blotch or fly speck on trees and shrubs other than pomaceous ones, though he does not mention any host plant by name, nor does he distinguish between sooty blotch and fly speck, because he regarded them as identical.

The writer has observed a sooty blotch on the twigs or stems of peach, Prunus Persica (L) Stokes, and blackberry, Rubus nigrobaccus B. (Fig. 19), both of the family Rosaceae, and on black mustard, Brassica nigra (L) Koch. (Fig. 20), of the family Cruciferae.

Various authorities regard the Rhode Island Greening, Peck's Pleasant, Rome, Baldwin, and Northern Spy apples, and Anjou, Lawrence, and Kieffer pears as those on which the fungus is most commonly found in North America. English writers report the Newton Wonder apple and Catillac pear, as most frequently bearing the

PLATE IV



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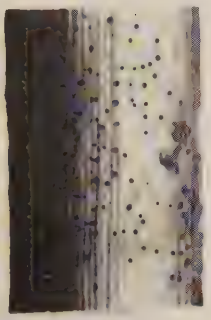

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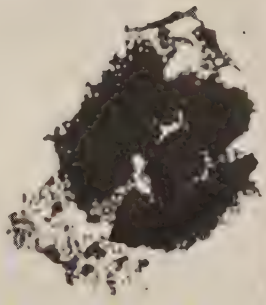

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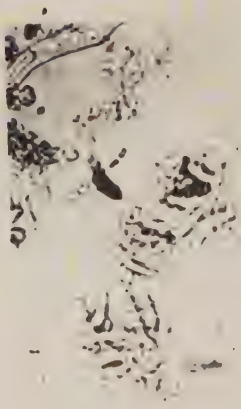

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fungus. However, it has been the writer's experience in dealing with sooty blotch, that in a season of considerable rainfall during the late summer, especially in orchards poorly pruned, the trouble was generally present on the fruit of nearly all varieties. For example, in one Illinois orchard in 1917, he found sooty blotch on the fruit from practically every tree and secured material from apples of twelve varieties, which are not specifically mentioned in the literature as those on which the fungus appears.

III. CONTROL

Sooty blotch, being superficial, comparatively slow growing, and appearing rather late in the season, is commonly well controlled in orchards properly located as regards air and water drainage, where correct methods of orchard management are followed.

On the other hand, it is practically impossible to exclude it from orchards, on sites poorly located (Howitt 1911). Fletcher (1912), Selby (1900), and Sheldon (1905) recommend the selection of an elevated site, where the trees will secure sufficient air and sunshine. In Illinois, in 1916, 1917, and 1918, according to my own observations, the trouble was much more commonly found in unpruned than in pruned orchards, and in vigorous young trees than in older more open-headed ones. The year 1917 was comparatively rainy during the latter part of the growing season. The conditions were reversed during 1918. Orchards under observation at Farmingdale and Clinton, Illinois, fairly well pruned to admit sunshine and air, and located on elevated sites, were not sprayed for the control of fungi in 1918. Scab *(Venturia inaequalis),* blotch *(Phyllosticta solitaria),* and black rot (*Physalospora Cydoniae*) were common. Not an apple, however, was found with sooty blotch. In the Farmingdale orchard, moreover, during the previous year, which was one of moderate rainfall during the latter part of the growing season, the trouble had been found wide-spread and abundant. It thus appears that the

fungus is extremely susceptible to unfavorable environmental conditions.

Proper pruning is important in preventing the occurrence of sooty blotch in fruit trees. Opening the trees to sunshine and air should be the first measure taken to combat the trouble.

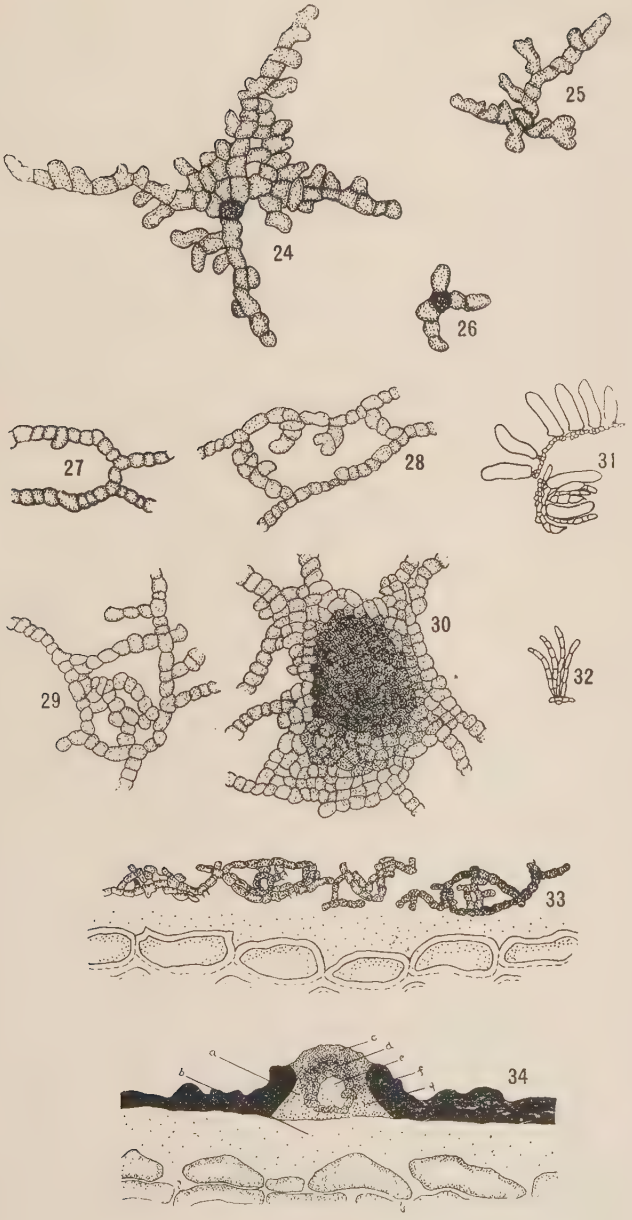
Clinton (1906) reports the sooty blotch as noticeably injurious in Connecticut orchards, "even where they have been sprayed". With this exception, the fungus has generally been reported easy of control when a regular spray schedule was followed. Usually this control comes about as an incidental result (Scott 1906, and Beach 1912), of other applications of spray material in the schedule.

The first recorded experimental work carried on for the control of sooty blotch was that of Lamson, on pears (1894). He reports that spraying with Bordeaux mixture was effective in controlling the trouble. His formula was 6 lbs. copper sulfate, 4 lbs. lime, in 22 gallons of water. Lamson's results, of special value in showing gradations of control, are tabulated as follows:

	Free from spot	Slightly spotted	Badly spotted
Unsprayed	18%	57%	25%
Sprayed	77%	23%	0%

Since that time, coincident with the gradual improvement in the formula for Bordeaux mixture, and more knowledge of its limitations, as well as advantages, in sooty blotch control, other fungicides have been discovered and tested. Lamson (1903), with a 5-5-50 Bordeaux mixture, reports that in spraying apples for scab, primarily, 77% of the fruit harvested was free from sooty blotch, 23% slightly spotted, and none badly spotted. Selby (1906) suggests an application of 4-4-50 Bordeaux mixture when the apples are the size of hickory nuts. An exception is made in case of apples like the Maiden Blush and Grimes varieties, when the spray should be applied earlier to avoid russetting the fruit. Norton and Seymour (1907) recommend Bordeaux mixture when the

PLATE V



fruit is one quarter grown. Stevens (1910) urges the adoption of a regular spray schedule of six applications, using Bordeaux mixture.

It may sometimes be necessary, in severe cases, augmented by rainy weather in late summer, to make more than the usual number of fungicidal applications. Wilcox (1905) believes that control of sooty blotch will be insured by spraying against apple scab, supplemented by one or more applications in July, a program also urged by Rolfs (1907). Howitt and Caesar (1917) recommend the application of the regular scab sprays early in the season, using lime sulfur as the fungicide. These are to be followed by an early August application, especially for sooty blotch control. Coons and Nelson (1918) state that it is often the practice in Michigan to use Bordeaux mixture late in July or up to the middle of August, as a supplement to the regular lime sulfur sprays.

It is worthy of note in this connection that Clinton and Britton (1912), and Blair *et al.* (1916), have found arsenate of lead to be of some fungicidal value, since it is slightly effective in sooty blotch control.

Some work has recently been done with a view to testing the relative effectiveness of the two standard fungicides, lime sulfur and Bordeaux mixture, in the control of sooty blotch. Ballou (1912) states that in Ohio the trouble was thoroughly controlled with one application of lime sulfur, the spraying being done late in July. He also shows that this material was as effective as Bordeaux mixture. Blair *et al.* (1916) report Bordeaux mixture superior to lime sulfur. They show in addition, that lime sulfur with arsenate of lead added, was slightly superior to lime sulfur alone, but adding arsenate of lead to Bordeaux mixture did not increase its fungicidal effect. Pickett *et al.* (1918) state that both Bordeaux mixture and lime sulfur, when used separately, completely controlled sooty blotch in 1913 and 1914, while as high as 25% infection was found in the check plots.

IV. GENERAL DISCUSSION

It has been shown that the names sooty blotch and fly speck have been confounded, and some authors have held that the two are but different forms of the same fungus. The morphological studies so far carried on by the writer, however, do not enable him to regard the sooty blotch and fly speck as caused by the same fungi, for the following reasons:

On many apples, collected at various times of the year, from Illinois and other states, showing a large amount of sooty blotch, no fly speck was present (Frontispiece).

It has often been observed, that where colonies or thalli of the fly speck and sooty blotch fungi approach each other, one of these fungi exerts an inhibiting or retarding effect upon the growth of the other, so that, for example, a nearly circular colony of the fly speck fungus may be almost completely surrounded by sooty blotch, yet the line of demarkation between the two be sharp and clearly marked (Fig. 18).

In other instances, a colony of one of the two fungi may grow toward a colony of the other fungus, until the two meet, then one may proceed to surround the other but not to grow into it. The condition exhibited is much like that frequently found on agar plates, where colonies of fungi or bacteria inhibit the growth of each other, and constitutes a strong argument that fungi which can so inhibit growth of each other are not of the same species. While this inhibition or antagonism of sooty blotch by fly speck or *vice versa* is a very common phenomenon, cases do frequently occur where one of these fungi grows into the colony of the other, such as Rhizopus may grow through a colony of Penicillium.

The morphology of the cell aggregations of sooty blotch and fly speck is dissimilar as to the size and external appearance (Fig. 18), and internal appearance (Figs. 15, 17).

The mycelium radiating from the cell aggregations of sooty blotch (Fig. 9), has been discussed. The mycelium radiating from the fly speck is very fine and hyaline, and is of quite different character than that of sooty blotch.

Finally, there has been observed a marked difference in the geographical range of the two fungi, by the writer and others. J. H. Gourley[7] of New Hampshire, in a letter to the writer, states: "It has been very apparent to me since being in this country that the fly speck does not develop as much as it did out in Ohio."

In view of these several points of evidence as to the independence of sooty blotch and fly speck, and the fact that their general aspect is quite dissimilar, any assumption of their identity would be quite gratuitous. The burden of proof must rest with any who make such an assumption.

While the writer has made no studies, as yet, as to the dissemination of sooty blotch, except the observation regarding the presence of chlamydospores, it was noted on examination of hundreds of apples of many varieties, from various parts of the United States, that in a very large percent (80-90) of cases, the fruit showed more sooty blotch at the stem end (Frontispiece), than elsewhere. This fact is presumably correlated with the dissemination of chlamydospores, by air, during the latter part of the growing season.

It was found that sooty blotch could be easily removed, with no damage to the apples, by immersing them for three to six minutes in Javelle water. The apples were then well washed and rinsed in running water and allowed to dry. The formula used in preparing Javelle water is as follows:

JAVELLE WATER

Bicarbonate of soda.....4 lb.
Chloride of lime.....1 lb.

Put soda in kettle over fire, add 1 gallon boiling water, let boil 10-15 minutes, then stir in the chloride of lime, so as to avoid the formation of lumps. Use when cool. The sodium hypochlorite is the effective reagent in destroying the fungus, by oxidation. It is believed that a practicable method can be developed, commercially, to enhance the sale price of blotched fruit, by removing the fungus.

[7] Letter of November 6, 1918.

In the literature, the sooty blotch fungus as observed on apple and pear fruits, is held to be morphologically similar with the exception of Salmon and Wormald's (1916) report. They state, after a description of sooty blotch on apples, in England, that its appearance on pears is very much the same, except that on apples there are very numerous "minute black specks". It is very likely that the sooty blotch, as Salmon and Wormald observed it, was a comparatively young stage, since in studying the trouble in Illinois on several varieties of pears, it was noted that the very small black "specks", primordia of pycnidia, did not begin to appear until October. This was about the same time that similar "specks" were forming on apples.

Martin (1918) describes "Brown Blotch of the Kieffer Pear", which he believes is probably closely related to the sooty blotch fungus, but is distinguished by its smaller size, its straighter connecting strands, and that it burrows into the cuticle, causing hypertrophy of the subcuticular layers. It is clearly evident that the disease Martin describes is not caused by the same fungus the writer has treated in these pages.

V. SUMMARY

1. Sooty blotch is a common trouble of apples and pears, of considerable economic importance, in North America and England.
2. It is entirely superficial, and does not cause rot or bring about any perceptible host malformation.
3. It was found on all varieties of apples examined, when conditions were favorable for the fungus.
4. Three thallus types have been observed, the fern-like type (Fig. 7), the honey comb type (Fig. 11), and the reticulate type (Fig. 12).
5. Pycnidial development is commonly by the symphogenous method (Figs. 27-30).
6. The fungus has been known as:

Dothidea pomigena Schw.

Asteroma pomigena (Schw.) fide Curt. in Sprague.

Phyllachora pomigena (Schw.) Sacc.
Leptothyrium Pomi Selby.

but does not belong to any of these.

7. Its characters warrant the erection of a new genus.

8. For this the name *Gloeodes* is proposed.

9. The names fly speck and sooty blotch have been commonly confounded, and some have held that the two merely represent forms of one fungus. The evidence is opposed to this view and the two should be regarded as separate fungi, unless full proof that they are connected can be adduced.

10. Arguments against the fly speck and sooty blotch being identical are: (a) the two are frequently found separate; (b) an antagonism often appears to exist between the two, as a sharp line of demarkation is observed when their colonies approach each other; (c) the morphology of the cell aggregations is dissimilar; (d) the mycelium radiating from the cell aggregations is dissimilar; (e) there is a marked difference in geographical range of the two fungi.

11. Sooty blotch is controlled by correct orchard management.

12. The fungus does not spread appreciably in storage.

13. Sooty blotch was easily removed from the surface of apple fruits after immersion in Javelle water for a short time.

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Symptoms of disease given. Reports effective control on pears by spraying.

Taft, L. R. and Davis, G. C.

1895. Fruit Spot. (*Phyllachora pomigena* (Schw.) Sacc.) *In* The Pests of the Orchard and Garden. Mich. Agr. Exp. Sta. Bul. 121, p. 22.
Noted as troublesome in Michigan.

Powell, G. H.

1896. A fungous disease of the apple. Garden and Forest *9*, p. 474-475.
The term, Fly Speck, used to include both forms. Claimed that the tissue around "disease" spots shinks. Market value of affected fruit injured.

Beal, W. J.

1897. Fly Speck. (*Leptothyrium Pomi* (Mont. & Fr.) Sacc.) (*Labrella Pomi*) *In* Diseases of the Apple. Mich. Hort. Soc. Rpt. 27, p. 180.
A popular description. Classed as a saprophyte.

Selby, A. D.

1897. Sooty fungus and fly-speck fungus. *In* Some diseases of orchard and garden fruits. Ohio Agr. Exp. Sta. Bul. 79, p. 133-134.
Names apples and pears as hosts. States both forms are commonly found together on apple. Unable to culture fungus.

Sturgis, W. C.

1898. On the cause and prevention of a fungus disease of the apple. Conn. (New Haven) Agr. Exp. Sta. Rpt. 21, p. 171-175.
Reports on the morphology, host susceptibility, and control methods necessary with respect to sooty blotch.

Beach, S. A., Lowe, V. H., & Stewart, F. C.

1899. Sooty Blotch. *Phyllachora pomigena* (Schw.) Sacc.)
Fly Speck. *Leptothyrium pomi* (Mont. & Fr.) *In* Common Diseases and Insects Injurious to Fruits.
N. Y. (Geneva) Exp. Sta. Bul. 170, p. 383-388.
Believe the "diseases" distinct, though associated. State that pears also subject. Control measures suggested.

Selby, A. D.
1900. Sooty Fungus and Fly-speck Fungus. *Leptothyrium pomi* (Mont. & Fr.) Sacc.) *In* A Condensed Handbook of the Diseases of Cultivated Plants in Ohio. Ohio Agr. Exp. Sta. Bul. 121, p. 13-14, fig. 12.
Describes fungus. Thought to spread in storage. Control measures are recommended. First to place the two under one technical name.

Clinton, G. P.
1901. Nomenclature. *In* Apple Scab. Ill. Agr. Exp. Sta. Bul. 67, p. 124.
After an examination of Schweinitz' original specimen of *Dothidea pomigena*, concludes that it is not the scab fungus as generally suspected, but more like the "fly-speck fungus" in its macroscopic appearance.

Orton, W. A.
1902-07. Sooty Blotch and Fly Speck. *In* Yearly Summary of Plant Diseases in the United States. Dept. of Agr. Yearbooks, 1902, p. 715; 1905, p. 603; 1906, p. 499; 1907, p. 577.
Reports occurrence of the "diseases" when common in the various states.

Saccardo, P. A.
1902. Leptothyrium Pomi (Mont. et Fr.) Sacc. Syll. Fung. 16, p. 986.
Gives a technical Latin description. Uncertain as to spores being present. Reports fungus on apples in Italy.

Clinton, G. P.
1903. Fly Speck. Sooty Blotch. *In* Notes on Parasitic Fungi. Conn. Agr. Exp. Sta. Rpt. 1903, p. 299-302.
Brief descriptive notes.

Faurot, F. W.
1903. Sooty Mold. *Leptothyrium pomi* (Mont. & Fr.) Sacc.) *In* Rpt. of Fungous Diseases Occurring on Cultivated Plants during the Season of 1902. Mo. State Fruit Exp. Sta. Bul. 6, p. 8-9.
A minor trouble but very common Fly Speck also caused by same fungus. List of susceptible apple varieties given. Spraying with Bordeaux mixture controls the "disease."

Lamson, H. H.
1903. Sooty Spot. Apple. Pear. *In* Fungous Diseases and Spraying. N. H. Agr. Exp. Sta. Bul. 101, p. 60-61, 65.
Description of fungus. Satisfactory results from spraying recorded.

Macoun, W. T.

1903. Sooty Fungus or Fly Speck Fungus. *Leptothyrium pomi.* *In* Report of the Horticulturist. Canada Central Exp. Farm Rpt. 1902, p. 111.

Fungus described. Geographical occurrence in Canada noted. Treatment suggested.

Rabenhorst, L.

1903. Leptothyrium Pomi (Mont. et Fries) Sacc. Kryptogamen Flora von Deutschland I. 7, p. 337.

Gives a technical description in German. Lists *Labrella Pomi* in synonymy. Reports fungus on the epicarp of apples from France and Rhode Island.

Longyear, B. O.

1904. Sooty Blotch. *In* Fungous Diseases of Fruits. Mich. Agr. Exp. Sta. Spec. Bul. 25, p. 14.

Briefly describes the fungus. Names varieties of apples and pears most commonly affected. Control measures suggested.

Sheldon, J. L.

1905. Sooty Blotch and Fly Speck. *In* A Rpt. on Plant Diseases of the State. W. Va. Agr. Exp. Sta. Bul. 96, p. 77.

Advises the selection of site where trees will secure air and sunshine. Bordeaux will check the trouble.

Wilcox, E. M.

1905. Fly Speck. *Leptothyrium pomi* (Mont. & Fr.) Sacc.)
Sooty Blotch *Phyllachora pomigena* (Schw.) Sacc.)
In Diseases of the Apple, Cherry, Peach, Pear, and Plum: with Methods of Treatment. Ala. Agr. Exp. Sta. Bul. 132, p. 93-94, 102-103. Pl. II, fig. 5.

Gives their geographical occurrence. Discusses morphology. Expresses doubt as to nomenclature. Claims they spread in storage. Recommends control measures.

Clinton, G. P.

1906. Apple. Sooty Blotch. *Phyllachora pomigena.* *In* Fungous Diseases for 1906. Conn. Agr. Exp. Sta. Rpt. 1906, p. 307-8.

"One of the most serious fungous troubles of the apple in Conn."

Macoun, W. T.

1906. Sooty or Fly Speck Fungus. *Leptothyrium pomi.* *In* Report of the Horticulturist. Canada Exp. Farms Rpt. 1906, p. 123-124.

Describes fungus. States that it spreads in storage.

Scott, W. M.

1906. The Control of Bitter Rot. U. S. Dept. of Agr. Bureau Plant Industry Bul. 93, p. 27.

The control of sooty blotch as an incidental result of sprays for bitter rot affirmed.

Norton, J. B. S., and Symons, T. B.

1907. Fly Speck. *Leptothyrium pomi. In* Control of Insect Pests and Diseases of Md. Crops. Md. Agr. Exp. Sta. Bul. 115, p. 177.

Recommended spraying with Bordeaux mixture when fruit is one-fourth grown.

Shear, C. L.

1907. *Leptothyrium pomi* (Mont.) Sacc.? *In* Cranberry Diseases. U. S. Dept. Agr. Bureau Plant Industry Bul. 110, p. 44, illus.

Reports occurrence of "flyspeck" on cranberries. Figures the fungus in cross section. Not certain of finding spores.

Rolfs, F. M.

1907. Fly Speck. *Leptothyrium pomi* (Mont. & Fr.) Sacc.)
Sooty Blotch. *Phyllachora pomigena* Schw. Sacc.)
In Fruit Tree Diseases and Fungicides. Mo. State Fruit Exp. Sta. Bul. 16, p. 8.

Brief descriptive notes of the "diseases" on apples. Pears are also affected. Control measures recommended.

Duggar, B. M.

1909. Sooty blotch and fly speck of the apple and other plants. *Leptothyrium Pomi* (Mont. & Fr.) Sacc.
In Fungous Diseases of Plants. P. 367-369, fig. 187-188. Boston, Mass.

Reports unpublished observations of Floyd, who holds that "sooty blotch and fly speck are apparently stages of the same fungus." Life history provisionally indicated.

Morse, W. J., and Lewis, C. E.

1910. Sooty Blotch and Fly Speck. *In* Maine Apple Diseases. Me. Agr. Exp. Sta. Bul. 185, p. 358, fig. 249.

Description of the fungus. Not so common in Maine as farther south. Effectively controlled by thorough spraying.

Salmon, E. S.

1910. Sooty blotch, a new fungous disease of apples. Card. Chron. 3: *48*, p. 443, fig. 187.

Its first reported appearance in England. A "disease" which "spreads on stored apples."

Lists susceptible varieties. Spray schedule for control recommended.

Smith, R. I., and Stevens, F. L.

1910. Fly Speck. (Leptothyriose). *In* Insects and Fungous Diseases of Apple and Pear. N. C. Agr. Exp. Sta. Bul. 206, p. 110, fig. 39.

A superficial fungus of minor importance. Controlled by use of the spray treatment suggested.

Hewitt, J. L., and Hayhurst, P.

1911. Fly-Speck Fungus. Sooty Fungus. *In* Diseases of Apple Trees and Fruit Caused by Fungi and Insects. Ark. Agr. Exp. Sta. Bul. 109, p. 439.
Stated that the fungus occurs on branches and twigs of apple trees as well as other plants in the orchard, but no specific examples cited.

Howitt, J. E.

1911. Sooty Blotch of Apple. *In* Ontario Agr. Col. and Exp. Farms Annual Rpt. 29, p. 51, illus.
Brief descriptive notes. Bordeaux mixture when apples size of hickory nuts recommended in control.

Ballou, F. H.

1912. The Rejuvenation of Orchards. Ohio Agr. Exp. Sta. Bul. 240, p. 511.
Sooty fungus controlled with lime-sulfur or Bordeaux mixture applied late in July.

Beach, S. A.

1912. Sooty Blotch. Fly Speck. *In* Spraying Practice for Orchard and Garden. Iowa Agr. Exp. Sta. Bul. 127, p. 52-53, 61-62.
Spray schedule for control.

Brooks, Chas.

1912. Sooty Blotch and Fly Speck. *Leptothyrium pomi.* *In* Some Apple Diseases and Their Treatment. N. H. Agr. Exp. Sta. Bul. 157, p. 15, fig. 17.
Dependent on moist weather for development. Readily controlled by spraying and pruning.

Clinton, G. P., and Britton, W. E.

1912. Tests of Summer Sprays on Apples, Peaches, etc. Conn. Agr. Exp. Sta. Rpt. 1911, p. 357.
Lead arsenate used alone gave noticeable control.

Quaintance, A. L., and Scott, W. M.

1912. Sooty fungus and fly speck. *In* The More Important Insect and Fungous Enemies of the Fruit and Foliage of the Apple. U. S. Dept. Agr. Farmers' Bul. 492, p. 36-37, fig. 21.
Give description. Disease is common in eastern states. Regular spray schedule, appended, will control.

Stevens, F. L.

1913. Phyllachora pomigena (Schw.) Sacc. Leptothyrium pomi (M. & F.) Sacc. *In* The Fungi Which Cause Plant Disease, p. 220, 529.
Gives morphology of the fungi. Notes meager knowledge of life histories.

Stevens, F. L., and Hall, J. G.

1913. Sooty Blotch. *Phyllachora pomigena* (Schw.) Sacc. Fly Speck. *Leptothyrium pomi* (Mont. et Fr.) Sacc.) *In* Diseases of Economic Plants, p. 94-95, fig. 38. New York City.
Give description of fungus, with control measures.

Sears, F. C.

1914. Sooty Blotch and Fly Speck. *In* Productive Orcharding, p. 169. Philadelphia.
Believes the two "diseases" similar, or may even be caused by same fungus. Superficial. Orchards sprayed for scab usually show very little of it, tho one later application may be necessary.

Theisen, S. J., and Sydow, H.

1915. *Phyllachora pomigena* (Schw. sub *Dothidia* Sacc. *In* Dothideales Annales Mycologici 13: p. 575.
Authors list *P. pomigena* under doubtful species.

Wilkinson, A. E.

1915. Sooty blotch and fly-speck fungus. *Leptothyrium pomi* (Mont. & Fr.) Sacc.) *In* The Apple, p. 226-227, fig. 102. Boston, Mass.
Brief general notes as to appearance and salability of affected fruit are given, with list of most susceptible varieties. Spray treatment recommended.

Blair, J. C., et al.

1916. Field Experiments in Spraying Apple Orchards. Ill. Agr. Exp. Sta. Bul. 185, p. 191, 202, 204-5.
The relative merits of Bordeaux mixture and lime sulfur in sooty blotch control discussed. Reported slight control with arsenate of lead used alone. Spray schedule recommended.

Higgins, B. B.

1916. Nomenclature of the fungus. *In* Plum wilt. Its nature and cause. Ga. Agr. Exp. Sta. Bul. 118, p. 13, 14.
Discusses his reasons for the name he gives plum wilt.

Salmon, E. S., and Wormald, H.

1916. Sooty Blotch of the Pear. *In* Gard. Chron., *59;* p. 58-59, fig.
The "disease" reported as present on Catillac pears. Description of symptoms. Claimed to be second to Thuemen (1879) in recording "disease" on pears.

Stevens, F. L.

1916. A convenient, little-known method of making micromounts of fungi. Phytopath., 6, p. 367.
Describes the use of celloiden for this purpose.

Winn, C. G.

1916. The Apple Crop of 1915. Trans. Ill. Hort. Soc. N. S. Vol. 49, p. 351, 352.

Reports serious infection of sooty blotch in unsprayed orchard, while trees nearby, sprayed three times with lime sulfur, were clean. "Clouded" fruit sold in Chicago for much less than clean fruit.

Whetzel, H. H., and Hesler, L. R.

1916. Sooty Blotch. *In* The Fruit Industry of New York State. N. Y. Dept. of Agr. Bul. 79, *I*, p. 869-870, fig. 244-245.

Describe fungus. Fly Speck is said to be another form. The late spray for scab should control.

Hesler, L. R., and Whetzel, H. H.

1917. Sooty Blotch and Fly-Speck. *Leptothyrium pomi* (Mont. & Fr.) Sacc. *In* Manual of Fruit Diseases. p. 104-108, fig. 28-29. New York.

Fungus described. Susceptible varieties of apples and pears listed. Geographical range noted. Provisional life history sketched. Control measures recommended.

Howitt, J. E., and Caesar, L.

1917. Sooty Blotch and Fly Speck. *In* The More Important Fruit Tree Diseases of Ontario. Ont. Agr. Col. and Exp. Farms Bul. 257, p. 12, illus.

Apples not injured as fungus is superficial. Affected fruit rendered unattractive, reducing sales. Control measures recommended.

Coons, G. H., and Nelson, Ray.

1918. Sooty Blotch. Fly Speck. (*Leptothyrium pomi*).

In The Plant Diseases of Importance in the Transportation of Fruits and Vegetables. Am. Ry. Perishable Freight Assoc. Circ. 473-A, p. 16, fig. 19.

The presence of apples showing such superficial blemishes "in shipment is indicative of low-grade fruit, not properly sprayed."

Martin, G. W.

1918. Brown Blotch of the Kieffer Pear. In Phytopath. *8*: 5, p. 234-8, fig. 9.

Description and experimental data. Probably closely related to *Leptothyrium pomi*, but distinguished by its smaller size, straighter connecting strands, and that it burrows into the cutin and causes hypertrophy of the subcuticular layers. Spray schedule recommended.

Pickett, B. S., et al.

1918. Spraying Apple Orchards in 1913 and 1914. Ill. Agr. Exp. Sta. Bul. 206, p. 493.

Both Bordeaux mixture and lime-sulfur, used separately, completely controlled sooty blotch in both seasons. As high as 25% infection found in check plots.

Kempton, F. E.

1919. The Origin and Development of the Pycnidium.

Thesis for degree of Ph. D. U. of Illinois, 1918. (Accepted for publication by the Bot. Gaz.)

A general discussion of pycnidial development with many illustrated examples.

EXPLANATION OF PLATES

All plates are from photo-micrographs. The magnification used in Plates 1-4 is indicated in connection with the figures. The drawings for Plate 5 were made with the aid of a Bausch and Lomb drawing apparatus and a Leitz number six objective, giving a magnification of approximately 1,100 diameters, and are reduced two-thirds.

PLATE I

Figure 7. Sooty blotch thalli of fern-like type, x 160.
Figure 8. Branching mycelium of one of the above thalli, x 300.

PLATE II

Figure 9. Immature pycnidia and mycelium, x 230.
Figure 10. Mature pycnidia and mycelium, x 230.
Figure 11. Sooty blotch thalli of the honey comb type, x 150.
Figure 12. Sooty blotch thalli of the reticulate type, x 230.

PLATE III

Figure 13. Cross section of sooty blotch pycnidium on apple, x 200.
Figure 14. Cross section of sooty blotch mycelium on pear, x 160.
Figure 15. Cross section of sooty blotch mycelium on apple, x 160.
Figure 16. Cross section of fly speck on watermelon, x 160.
Figure 17. Cross section of fly speck on apple, x 200.

PLATE IV

Figure 18. Antagonism of sooty blotch and fly speck on apple, x 2.
Figure 19. Sooty blotch and fly speck on blackberry, x 2.
Figure 20. Sooty blotch and fly speck on black mustard, x 2.
Figure 21. Sooty blotch pycnidium forced open, x 200.
Figure 22. Sooty blotch pycnidium with jagged aperture, x 230.
Figure 23. Spores and paraphyses of sooty blotch, x 230.

PLATE V

Figure 24. Well developed thallus of sooty blotch.
Figure 25. Younger stage of sooty blotch thallus.
Figure 26. Still younger stage of sooty blotch thallus.
Figure 27. A beginning stage in pycnidial formation; on apple bark.
Figure 28. Later stage in pycnidial formation; on apple skin.
Figure 29. Later stage in pycnidial formation.
Figure 30. Nearly mature pycnidium.
Figure 31. Conidia of sooty blotch.
Figure 32. Paraphyses of sooty blotch.
Figure 33. Cross section of sooty blotch mycelium.
Figure 34. Diagram of cross section of sooty blotch pycnidium.

Vita.

Arthur Samuel Colby was born at Tilton, N. H., July 4th, 1887. Attended the grade school, Tilton Seminary, and New Hampshire College graduating from the latter in June, 1911, with the degree of B. S. Taught Agriculture at the Pinkerton Academy, Derry, N. H., 1911-13.

Became Assistant in Pomology on part time at the University of Illinois, Urbana, Illinois, September 1, 1913. On instructional staff at the U. of I. while receiving the degrees of M. S. in Horticulture and Ph. D. in Botany from the University in 1915 and 1919 respectively. At present, Assistant Professor in Pomology at the University of Illinois.

Publications.

Various articles on the culture of fruits in the American Fruit Grower, and International Garden Club Magazine. *The Pruning of Blackberries* In Proceedings of the Society for Horticultural Science 1920-21.